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Differences in the relative abundance of abalone (*Haliotis iris*) in relation to the perceived status of two regional fisheries in New Zealand

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Abstract

Population survey results and commercial catch data were obtained for two fisheries (PAU 5 & PAU 7) for the New Zealand abalone *Haliotis iris*. PAU 5 had greater catch rates and greater relative abundance of harvestable abalone (≥ 125 mm shell length) than areas of PAU 7, but PAU 5 is perceived by participants to be vulnerable whereas PAU 7 is perceived as sustainable. Contrasts in the relative abundance of juveniles (abalone in cryptic habitat < 100 mm shell length) and pre-recruits (≥ 100, < 125 mm) appear to correlate with the perception of participants on the sustainability of the two fisheries. For areas within individual fisheries, population surveys in 1993 and again in 1995/96 revealed no differences in the relative abundance of harvestable individuals. However, increases in the frequency of juveniles, pre-recruits, and large patches (≥ 5 individuals) were recorded for two of the three areas surveyed in PAU 7. No differences in any of these indices were found for PAU 5. These results suggest that perceptions of the sustainability of the New Zealand abalone fisheries relate to the relative levels of pre-recruits, particularly those individuals in large aggregations, rather than the abundance of harvestable individuals.

Keywords: *Haliotis iris*, sustainability, diver behaviour, abundance, aggregations.

Introduction

Reviews of methodology for the assessment of abalone (*Haliotis* spp.) fisheries have emphasised the practical difficulties of estimating stock size and appropriate yields (Sloan and Breen 1988; Breen 1992; McShane 1997). These difficulties relate to the disaggregate stock structure of abalone (Shepherd and Brown 1993), and problems of censusing populations in shallow wave-exposed coastal habitats (McShane 1995).

All Australasian abalone fisheries are managed under a combination of output (catch quotas), and input (size limits) controls (Shepherd 1992). Although considerable research has been undertaken, management actions, and evaluations of management strategies, have been based more on qualitative assessments related to the perceptions of participants in the fishery, rather than on formal quantitative assessments (Shepherd 1992). The considerable commercial value of abalone fisheries demands defensible assessments and fishery-independent assessments are presently being undertaken in most Australasian abalone fisheries.

In New Zealand, quantitative assessments linked to population surveys (*Haliotis iris* Martyn) have been conducted in two major regional fisheries: PAU 5, encompassing southern New Zealand; and PAU 7, the top of the South Island including D'Urville Island (McShane *et al.* 1994). Together, these fisheries account for more than half of the total annual catch of abalone from New Zealand (about 1200 t). Although not quantified, the general perception of the status of these regional fisheries differs considerably between participants in the two fisheries. PAU 5, the largest fishery with a total allowable commercial catch (TACC) of 442.8 t, is considered by many participants to be vulnerable and, reflecting this concern, participants successfully applied for a 10% reduction in the TACC in 1994. In contrast, PAU 7 is generally considered by participants as capable of sustaining the current TACC of 266.2 t.

Here, I present information on commercial catch data and population survey results for the two fisheries in the context of the contrasting perceptions of the participants. I discuss the behaviour of abalone divers as an important factor in determining the nature of the impact of fishing on abalone populations, and I examine the utility of alternative abundance indices in assessing stocks of abalone.

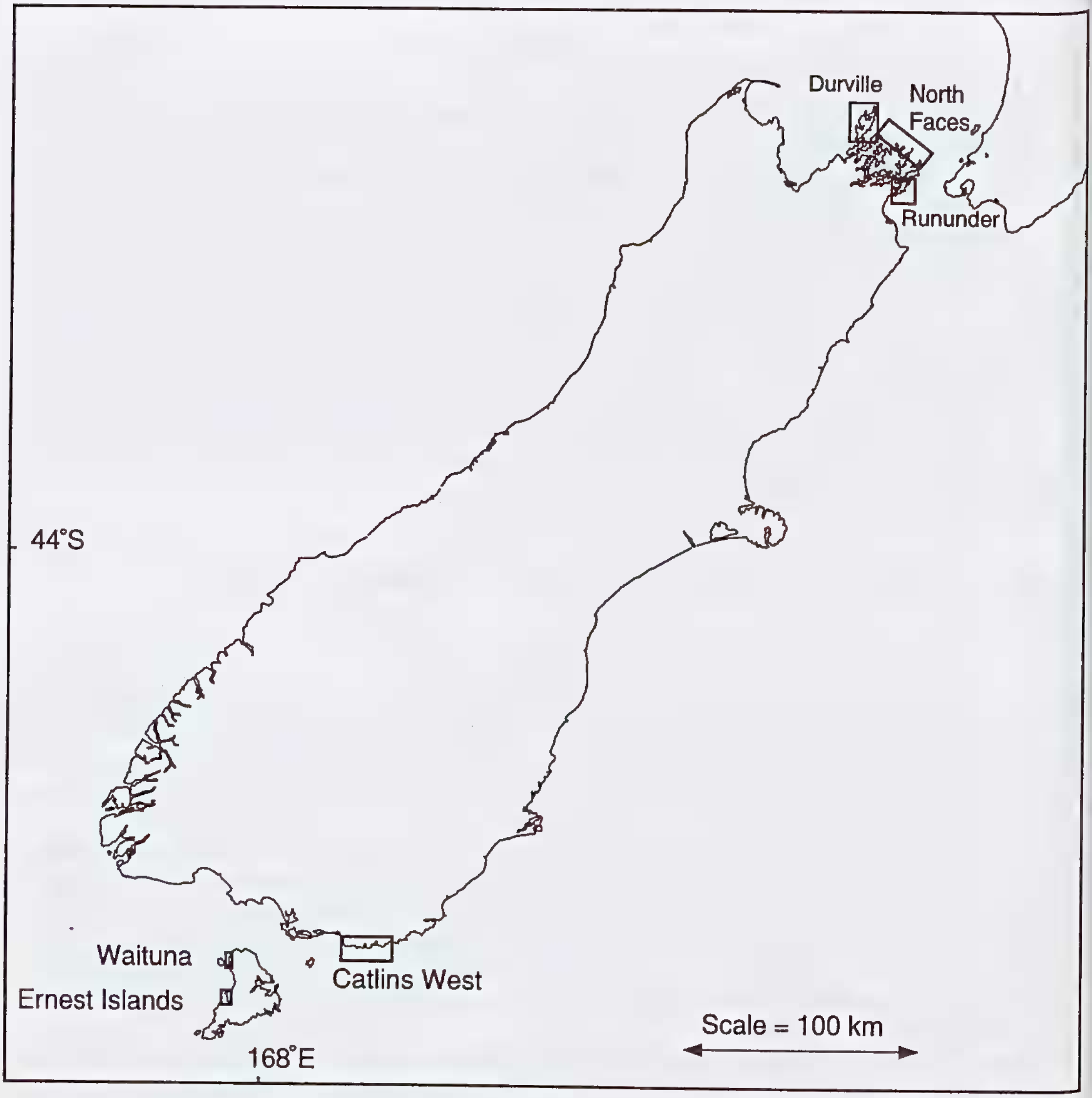

Figure 1. Locality map for areas surveyed in PAU 5 and PAU 7.

Materials and Methods

Commercial catch data were obtained from compulsory log books submitted by fishers. Catch and effort data are collected over lengths of coastline (about 100 km) which are either larger than, or overlap, those coastal areas considered for population surveys. This spatial subdivision of reporting requirements for catch and effort data reflects a uniform subdivision for reporting of all coastal fisheries in New Zealand and the utility of catch and effort data, other than reporting gross annual trends, is considered poor for the New Zealand abalone fishery (McShane *et al.* 1996).

Three areas were chosen for survey in PAU 5 and PAU 7 based on coastal habitat nominated by abalone divers as being important to their respective fisheries. Of these, Catlins (PAU 5), and D'Urville, North Faces, and Rununder (PAU 7) had successive population surveys undertaken. Two other areas in PAU 5 (Waituna, Ernest Islands) were considered as being subject to high exploitation rates (McShane *et al.* 1996) and were included for comparison with the other areas surveyed. Areas were about 20 km of coastline, except for D'Urville, North Faces, and Rununder which represent approximately 34, 88, and 35 km of coastline respectively. Access and weather largely determine the frequency of fishing in each area. The three areas surveyed in PAU 5 are often exposed to heavy seas, whereas the areas surveyed in PAU 7 may be considered as relatively sheltered (McShane *et al.* 1994).

For the purposes of survey, the coastline of each area was subdivided into 250 m strips and each strip was considered a potential sample site. Sites were allocated randomly and the number of sites sampled within each area was based primarily on its estimated available habitat, and on the variance in abundance of abalone estimated from preliminary surveys conducted in 1991 and 1992 (McShane *et al.* 1994). For areas of PAU 7, and Catlins in PAU 5, surveys were conducted 2–3 years apart according to sampling opportunities, and the perceived potential for measuring a significant fishing-induced change in the abundance of abalone in each area (McShane *et al.* 1996).

At each site two divers, one on each side of the research vessel, each searched for *Haliotis iris* on subtidal reef habitat for 10 min (McShane 1995). As *H. iris* has a preference for shallow habitat, divers searched habitat above 10 m depth. They used surface-supplied air which limited the searching area to a 100 m radius described by the air hose. Thus, at any one site, individual divers would sample two replicate subsites separated by tens of metres but by no more than 200 m. Two timed searches were made at each site and the frequency of patches of various sizes was recorded according to the method described by McShane (1995). Samples of no more than 4 individuals were collected from each patch encountered at each subsite.

Relative abundance data and the density of emergent abalone (i.e., those on open reef habitat visible to divers) were derived from patch frequency records. Patch size was classified according to the numbers of individuals per patch: patch1, 1–4; patch2, 5–10; patch3, 11–20; patch4, 21–40; patch5, 41–80; patch6, 81–160. Relative abundance data, derived from patch frequency data, were standardised to take into account searching and handling time as described by McShane (1996). All patches with 5 or more individuals were considered as large and targetted by abalone divers (McShane 1995). Estimates of the density of harvestable and pre-recruit abalone were made for each

Table 1. Summary data for surveys conducted for *Haliotis iris* in PAU 5 and PAU 7. Sample size (n) is the number of subsites surveyed on each occasion.

Area	Fishery	Date of first survey	$n_{(1)}$	Date of second survey	$n_{(2)}$
Rununder	PAU 7	October 1993	32	June 1996	32
North Faces	PAU 7	April 1993	28	May 1995	30
D'Urville	PAU 7	April 1993	24	November 1995	24
Waituna	PAU 5	August 1993	19	February 1995	34
Ernest Islands	PAU 5	no survey	–	June 1995	39
Catlins	PAU 5	November 1993	20	November 1996	18

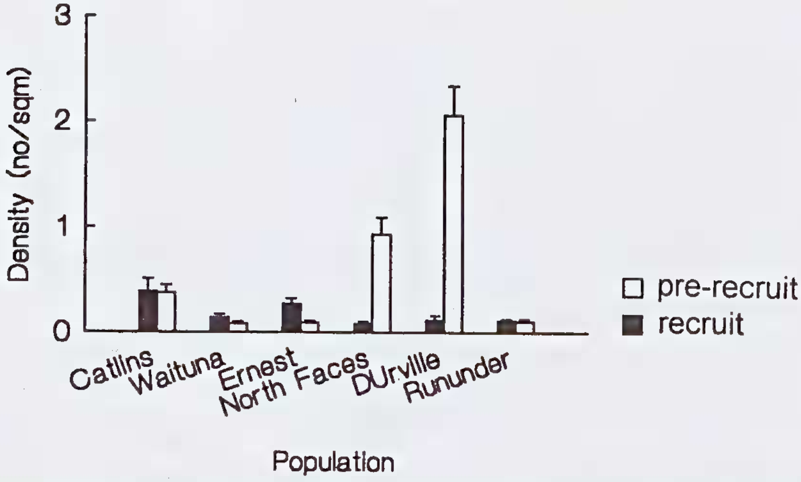

Figure 2. Comparison of the density of pre-recruit (under 125 mm) and harvestable *Haliotis iris* (= 125 mm) sampled from areas of PAU 5 and PAU 7. Data are means with s.e.

subsite by multiplying the density of emergent abalone by the relative proportion of individuals ≥ 125 mm, and individuals < 125 mm respectively.

A further 10 min was spent by each diver at each site searching for juveniles in under-boulder habitat. All specimens collected were measured for shell length to the nearest mm aboard the research vessel. Juveniles were not included in estimates of the relative abundance of harvestable or pre-recruit abalone. As the availability of juvenile habitat can vary from site to site, juvenile abundance data were considered semi-quantitative and are used mainly in expressing relative differences among areas within fisheries, and between fisheries, i.e., PAU 5 vs PAU 7.

Where appropriate, means of relative abundance data were compared by ANOVA after testing for homogeneity of variances with Cochran's test.

Results

Reliable catch and effort data were only available from 1989. There was interannual variation in catch rates in PAU 5 and PAU 7, but catch rates were consistently higher in PAU 5 than in PAU 7 (Table 2). There was no consistent trend in catch rates for either fishery.

There was significant variation in the relative abundance of *H. iris* among the areas surveyed during 1995/96 (Fig. 2). The areas surveyed in PAU 7 all had significantly lower densities of

Table 2. Total allowable commercial catch (TACC), catch, and catch per unit effort (CPUE) data for two fisheries for *H. iris* (PAU 5 and PAU 7). Data are shown for each fishery as catch (tonnes) and CPUE (kg per diver h).

	PAU 5			PAU 7		
Year	TACC	Catch	CPUE	TACC	Catch	CPUE
1989–90	459.5	459.5	67.7	263.5	248.6	40.7
1990–91	484.9	528.2	82.2	266.2	274.9	37.2
1991–92	492.1	486.8	58.2	266.2	275.1	35.1
1992–93	442.8	440.2	61.0	266.2	268.0	45.7
1993–94	442.8	440.4	56.6	266.2	255.5	46.2
1994–95	442.8	436.1	43.1	266.2	244.4	40.2

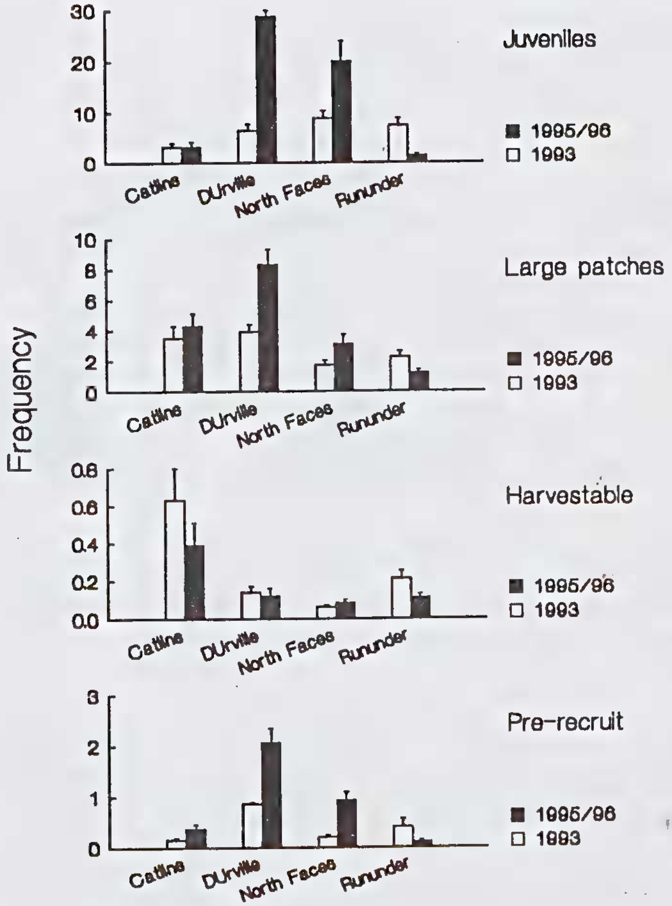

Figure 3. A comparison of the frequency of juveniles, large patches (≥ 5 individuals), harvestable individuals, and pre-recruit *Haliotis iris* in 1993 and 1995/96. Data are means with s.e. and are nos/10min (juveniles, large patches) or estimated nos/sqm (harvestable, pre-recruit).

harvestable individuals than Catlins or Ernest Islands in PAU 5 (by ANOVA $P < 0.05$). However, North Faces and D'Urville had significantly greater numbers of pre-recruits than the other areas surveyed.

There were significant increases in the frequency of juveniles recorded at D'Urville and North Faces, and a decrease recorded for Rununder in successive surveys (Fig. 3). There were increases in the frequency of large patches recorded for D'Urville and North Faces, but there was no significant change in the abundance of harvestable individuals for any of the areas surveyed (Fig. 3). However, increases in the abundance of pre-recruit abalone were shown for D'Urville and North Faces (by ANOVA, $P < 0.05$).

There were no obvious differences in the availability of juvenile habitat among localities within areas. Most sites had shallow boulder-strewn habitat which offered refugia for juveniles of *H. iris*. However, sites in areas of PAU 5 were clearly exposed to heavy wave action as most of the reefs surveyed showed evidence of mobility of boulders on shallow reef habitat. In contrast, most of the under-boulder habitat encountered on the shallow reefs in PAU 7 was colonised by crustose coralline algae and other biota typical of juvenile abalone habitat (c.f. Shepherd and Turner 1985).

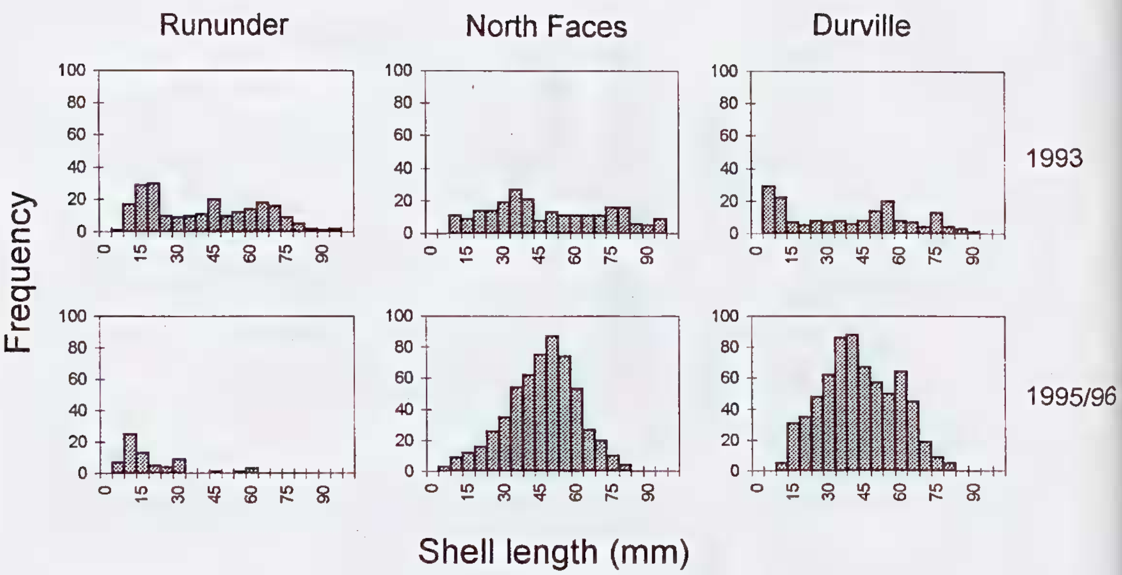

Figure 4. Length-frequency distributions of juvenile *Haliotis iris* sampled from under-boulder habitat in areas of PAU 7.

So few juveniles were found in PAU 5 that no length frequency distributions are presented. However, in PAU 7, cohorts of putative year classes were evident from length frequency distributions from the three areas (Fig. 4). A strong cohort of individuals 10–20 mm in length was apparent from Rununder and, for 1993, D'Urville. The decrease in the frequency of juveniles at Rununder in 1996 was associated with the loss of putative 2+ and 3+ year classes from the population (see McShane and Naylor 1995). Similarly, the strong increase in the frequency of juveniles and pre-recruits recorded for D'Urville and North Faces was associated with evident progression of juvenile year classes from 1993, and settlement in the years between the surveys (Fig. 4).

Discussion

Catch rates and estimates of relative abundance of harvestable abalone are inconsistent with the perceptions by participants of the status of two major regional abalone fisheries in New Zealand. Clearly perceptions of fishers are influenced by a range of factors including experience, motivation, and future expectations. Exploration of these factors is beyond the scope of this study, but differences in them may be expected among participants in the two fisheries. Perceptions of participants are discussed only in the context of their contrasting assessment of the status of two regional abalone fisheries and are described in relation to differences in the relative abundance of abalone.

Changes in the relative abundance of *Haliotis iris* were recorded in successive surveys over a two to three year period. However, these changes were associated with differences in the relative abundance of juveniles and pre-recruits rather than differences in the frequency of harvestable individuals.

There are two possible reasons for differences in the perceptions of participants in PAU 5 and PAU 7. First, fishing effort in PAU 5 has been traditionally concentrated in a relatively small spatial area of the fishery; Stewart Island (McShane *et al.* 1994). The perceptions of participants may reflect their experience of Stewart Island in a heavily fished area such as Waituna rather than a lightly fished area such as Catlins (McShane *et al.* 1996). Second, there are obvious differences in the recruitment potential among the two fisheries. Despite intensive searches of juvenile habitat, most sites surveyed in PAU 5 had no juveniles at all (McShane *et al.* 1996), and there were relatively few pre-recruits among the emergent abalone sampled. For North Faces and D'Urville there was a tenfold or greater difference in the relative abundance of juveniles than in areas surveyed in PAU 5 (McShane *et al.* 1994), and the size composition results suggested strong year classes present in areas of PAU 7. Furthermore, there was a significant increase in the abundance of pre-recruits for North Faces and D'Urville from 1993 to 1995 which was associated with an increase in the frequency of large patches.

A general pattern emerges from the survey results which suggest real differences in the productivity of the two fisheries. PAU 5 has mainly unproductive stocks characterised by an accumulation of large individuals and an infrequency of pre-recruits and juveniles (McShane *et al.* 1994). In contrast, consistent recruitment to the harvestable stock in PAU 7 may be expected from strong juvenile year classes and abundant pre-recruits. Thus, populations in PAU 7 are more likely to sustain regular fishing, but with a lower catch rate, than those in PAU 5.

Diver behaviour is clearly important in determining the impact of fishing on abalone populations. Simulation models suggest that selective fishing of aggregations (large patches) is a conservative fishing strategy because the harvest of disaggregated individuals involves substantial searching time (McShane 1996).

Realistic and spatially explicit models, which incorporate the aggregational structure of abalone populations and include the selective fishing behaviour of abalone divers need to be developed for abalone fisheries (see Allen and MacGlade 1986 for fish). Indices of juvenile and pre-recruit abundance, which may be important in shaping perceptions of abalone divers and hence their behaviour, will lead to better evaluations and more objective decision making in the management of abalone fisheries than the historical reliance on qualitative information.

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